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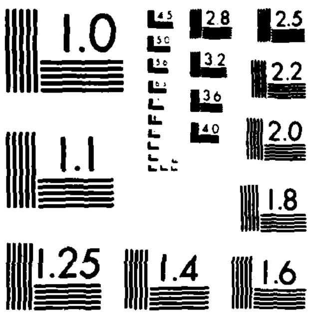

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APPLICATIONS OF SCIENTIFIC SATELLITE DATA ANALYSIS SYSTEMS TO SATELLITES P78-2, S3-4 AND P78-1

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Scientific Satellite Data Analysis Systems (SSDAS) have been developed and implemented for satellites P78-2 (SCATHA), S3-4 and P78-1. Analysis routines have resulted in the creation of data bases for multiple Air Force Geophysics Laboratory (AFGL) probes. System methods and analysis techniques used in the creation of SCATHA final atlas data bases are described. Analysis techniques for P78-1 and S3-4 probe data are also described.

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PREFACE

The authors wish to thank several members of the Space Data Analysis Laboratory of Boston College for their efforts during this contracting period.

Administrative assistance and encouragement were provided by the Director of the laboratory, Mr. Leo F. Power, Jr.

Analysis, programming and data base development efforts were performed by Kenneth Dieter, Brian Donovan, Kevin Martin, William McComish, Carolyn Parsons and Lisa Silva.

Miss Mary Kelly provided the necessary secretarial assistance.

I. INTRODUCTION

1.0 Overview

Scientific Satellite Data Analysis Systems (SSDAS) have been developed and implemented for space vehicles P78-2 (SCATHA), S3-4 and P78-1. The efforts described in this report were performed by the Space Data Analysis Laboratory (SDAL) of Boston College under contract to the Analysis and Simulation Section (SUNY) of the Air Force Geophysics Laboratory (AFGL). The contract number was F19628-81-C-0053.

The SSDAS provides a systematic approach to data base development for probe data. Data bases include ephemeris and attitude parameters as requirements dictated. Adaptations and modifications to the SSDAS were made for each spacecraft thus making each system unique; but common requirements for all three vehicles were satisfied through the use of program modules.

The overall SSDAS for the P78-2 Spacecraft Charging at High Altitude (SCATHA) spacecraft was described in a previous report (SCATHA-ANALYSIS SYSTEM, Dennis E. Delorey, AFGL-TR-81-0037). Modifications and updates to the system were required in order to provide the necessary data bases for the final atlas. Implementation of the system for all AFGL digital data received from the Eastern Space and Missile Center (ESMC), Patrick AFB, Florida has been completed.

The polar orbiting P78-1 payload included the AFGL High Latitude Particle Spectrometer (CRL-251). A data base of flux, attitude and ephemeris parameters has been created.

The S3-4 spacecraft had the following AFGL payloads: UV and VUV spectrometers, photometer, particle flux accumulator and a rotating calibration accelerometer (ROCA). Data bases for all full orbit operations of these instruments have, in general, been completed.

Succeeding sections will describe efforts related to each vehicle in more detail.

II. P78-2 (SCATHA)

2.0 SCATHA Satellite/Payloads

The SCATHA satellite was launched from the Eastern Test Range (ETR) on 30 January 1979 at 2142: (Z). It was successfully placed in near synchronous orbit for the purpose of investigating spacecraft charging at high altitude. The mission is providing data for the study of charging, discharging and plasma interaction phenomenae. The objectives of the program included studies of the interaction of charging and discharging phenomenae with SV operations and techniques designed to control SV charge; effects on spacecraft materials due to charging and discharging; studies of particles over a wide range of energies; and determination of magnetic field intensities due both to the environment and the spacecraft. On-orbit data and command/control communications are being performed by the Air Force Satellite Control Facility (AFSCF).

Orbital orientation provides two eclipse seasons each year. During these eclipse seasons, the spacecraft experiences a sequence of altitudes near synchronous altitude at local midnight.

The AFGL payloads for which data bases have been created are the Particle Beam Systems (SC4), which consists of the Electron Beam System (SC4-1) and the Positive Ion Beam System (SC4-2), and the Rapid Scan Particle Detectors (SC5).

The SC4 instrumentation consists of two independent systems designed to control spacecraft charging. The Electron Beam System (SC4-1) controls the ejection of electrons and Positive Ion Beam System (SC4-2) controls the positive ion charge (xenon ions).

These systems were developed in order to maintain the space vehicle ground at plasma potential; return a highly negative space vehicle ground to plasma potential; charge the spacecraft to a high positive potential with respect to the plasma (SC4-1); and charge the spacecraft to a high negative potential with respect to the plasma.

Thus, the SC4 can be used to discharge a charged vehicle or charge a spacececraft in a predictable manner. Interpretation of the effects of SC4 operations is accomplished by analyzing data from other detectors such as SC5 or the SC10 common mode parameters.

In the SC4-1 system, the electron source is a cathode. Beam currents are selectable through the use of a control grid; the angular spread of the electrons is commandable through the use of a focus element; and the energy of the beam of electrons is also commandable.

There are 6 selectable states for current and energy; and three choices of angular spread.

Commands to the SC4-2 instrument allow for the emission of a positive ion beam, a low energy electron beam, or a plasma of ions and electrons. Basically a cathode emits electrons which are accelerated toward an anode where they ionize the xenon gas atoms. Thus, a plasma is formed from which ions are extracted. Cylindrical apertures and grids form the beam. The instrument has 2 selectable bias voltages and 3 current levels for each voltage.

The SC5 Rapid Scan Particle Detectors (RSPD) were designed to make particle flux measurements of ions and electrons. The approximate energy ranges over which the measurements are taken are 50 eV to 3.5 meV for ions and 50 eV to 1.1 meV for electrons. Ion and electron data are taken simultaneously.

The SC5 package is made up of two identical sets of detectors. One set is mounted to look perpendicular to the reference spin axis of the space vehicle while the other set, perpendicular to the first set, views parallel to the vehicle reference spin axis. Each detector set consists of 2 Electrostatic Analyzers (ESA) and 2 Solid State Spectrometers (SSS).

Each ESA has two Spiraltron Electron Multipliers for detectors; one detector is for ions and the other is for electrons. These detectors have rectangular fields of view. Power control circuitry automatically shuts off the ESAs whenever the flux level exceeds predefined values.

Data is provided by low energy and high energy ESAs. Each ESA accumulates counts at 4 energy levels and also provides a background count measurement. The data are accumulated for 200ms at each energy level and thus a full set is acquired every second. The Solid State Spectrometers are referred to as anticoincidence and coincidence. The anticoincidence and coincidence detectors respectively perform the lower and higher enery measurements. As with the electrostatic analyzers, there are 5 energy channels for each SSS. The accumulation periods are also 200 ms.

Internal instrument logic provides an output for an energy channel if, and only if, the lower energy threshold for the channel is exceeded and the upper threshold is not exceeded.

The ESAs can be commanded to dwell at an energy range (channel) for up to 1024 accumulation periods (200 ms). Through ground command, the ESA detectors can be turned off while the SSS detectors remain in their normal operational mode.

The counts data for the ESA and SSS detectors is in the form of 12 bit digital readouts. Since the spacecraft has an 8 bit PCM system, each readout is split over two mainframe words.

In addition to the counts data, there are 17 housekeeping monitors, which provide temperature and voltage data.

The spacecraft telemetry subsystem provides for acquisition, storage, formatting and transmission of engineering and science data. This subsystem includes the timing and command distribution unit (TCDU), 2 primary PCM encoders (8192 bps), 1 auxiliary PCM encoder (512 bps), 2 baseband multiplexers, 2 S-Band transmitters, a microwave control assembly and radial and omni antennas.

The TCDU generates timing signals used by the spacecraft and experiments. It also generates the vehicle time code word (VCTW) used in providing a time-tag for the PCM data.

The primary encoders provide data at 8192 ± .01% bps in real time mode.

The specifics of the telemetry system are summarized in the following table:

8	bits/word
128	words/mainframe
1024	bits/mainframe
8192	bits/second
8	mainframes/second
.125	seconds/mainframe
128	mainframes/masterframe
16	seconds/masterframe
131072	bits/masterframe

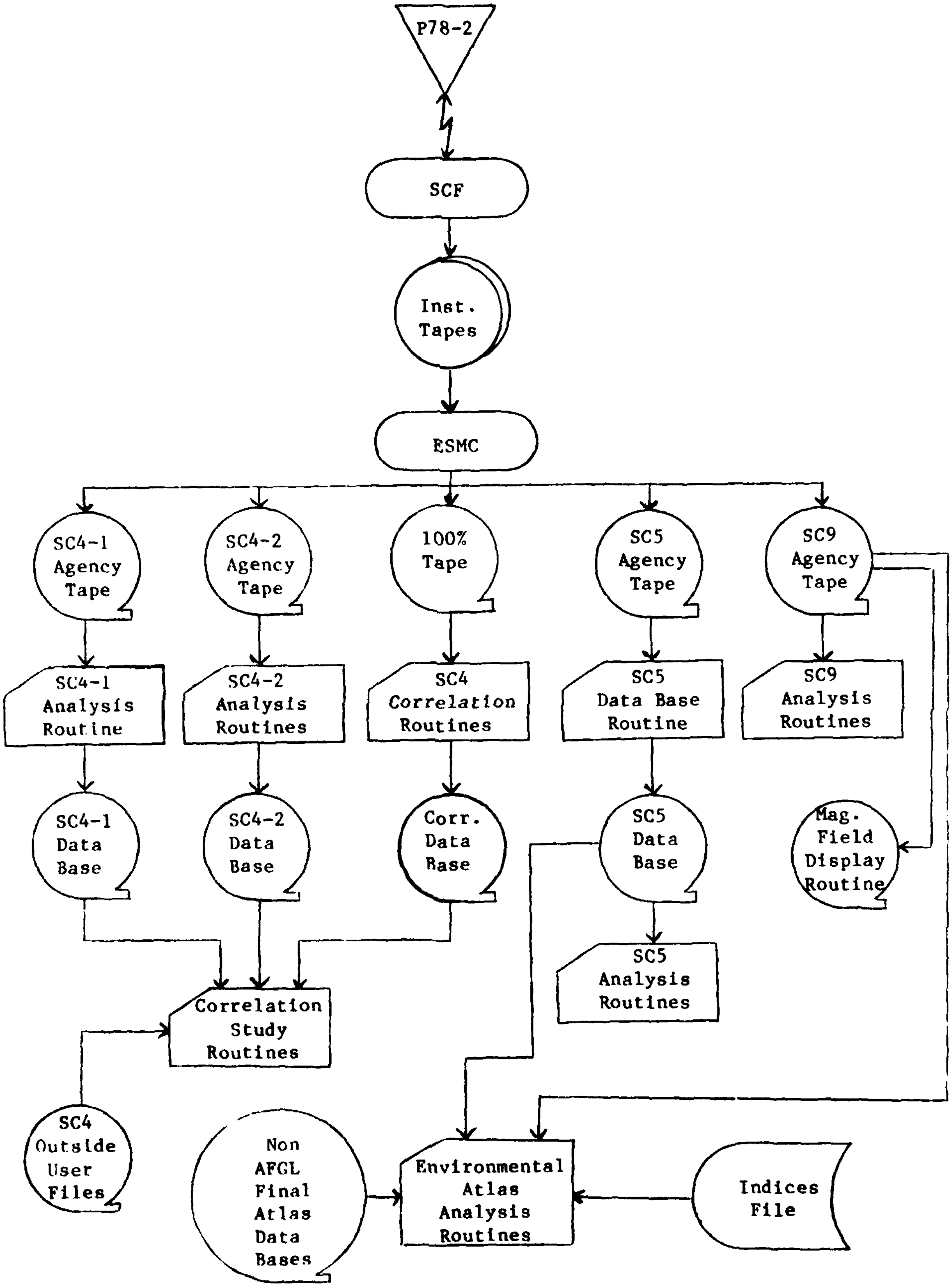
The tape recorders onboard the spacecraft record a serial bi-phase-level 8192 ± .01% bps PCM bit stream using a single data track. The recorders can accumulate approximately 12 hours of 8192 bps data. Tape recorder playback is at a rate of 65536 bps.

2.1 SCATHA Analysis System

The SCATHA analysis system was used in order to provide data bases and computer analysis results for the AFGL SC4 and SC5 detectors; magnetic field parameter data from the NASA GSFC SC11 detectors; common mode voltage data from the NASA GSFC SC10 detector; particle flux and distribution function data from the University of California at San Diego (UCSD) SC9 detectors. In addition, data bases were created and used in analysis routines developed to satisfy requirements for the AFGL environmental atlas.

The functional flow of data through the SCATHA analysis system is depicted in Figure 1.

The operation of the P78-2 spacecraft is performed by the Satellite Control Facility. Telemetry data from the spacecraft is recorded on instrumentation tapes at various remote tracking stations. Instrumentation tapes for the entire first year and selected periods thereafter were sent to the Eastern Space and Missile Center (ESMC) at Patrick AFB, Florida for digitization. The AFGL digital tape requirements included agency tape creation for SC4-1, SC4-2, SC5 and SC9 and 100% tapes. Each agency tape has 5 files: header, event, estimation module, magnetic field and telemetry data. Each telemetry file contains only the parameters specifically requested. The 100% tape contains data from the full telemetry stream for small time periods (which are generally coincident with SC4 operations). In general, there is one agency tape for SC5 and SC9 for each digitized day of data. SC4 agency tapes are generated only for days on which the SC4 was operated. When generated, there is one SC4-1 (and/or SC4-2) agency tape per day. The 100% tapes cover selected periods which are coincident with SC4 operaticns and multiple tapes may be received for days on which the SC4 was operated.



P78-2
SCF
Inst. Tapes
ESMC
SC4-1 Agency Tape
SC4-2 Agency Tape
100% Tape
SC5 Agency Tape
SC9 Agency Tape
SC4-1 Analysis Routine
SC4-2 Analysis Routines
SC4 Correlation Routines
SC5 Data Base Routine
SC9 Analysis Routines
SC4-1 Data Base
SC4-2 Data Base
Corr. Data Base
SC5 Data Base
Mag. Field Display Routine
SC5 Analysis Routines
Correlation Study Routines
SC4 Outside User Files
Non AFGL Final Atlas Data Bases
Environmental Atlas Analysis Routines
Indices File

Figure 1

The SC4-1 and SC4-2 analysis routines use agency tapes as input and result in a time history of commands sent to the instruments; engineering unit listings and displays; and data bases used for further study in either a stand-alone fashion or in conjunction with data from other probes. The data base includes engineering unit parameters and magnetic pitch angle, sun angle and ephemeris data as required.

The 100% tapes are used primarily to provide geophysical unit data from other detectors during SC4 operations. The raw telemetry data for such probes a the SC10 and transient pulse monitor (TPM) is extracted from the 100% tape, calibrated to engineering units, merged with attitudinal and ephemeri data (as required) and listings, plots and data bases created. These corre ion data bases are used along with the SC4 and other outside user files, e. urface Potential Monitor, in studying the effects of the SC4 beams syst on the spacecraft and its environment.

SC4-1, SC4-2 and SC-10 data bases have been created for all available digital data (received from ESMC). This includes first year operations plus selected operations from the second and third year of vehicle lifetime.

A detailed description of the SC4 telemetry parameters, instrument operation and computer analysis routines is contained in the final report of contract F19628-81-C-0018 (SCATHA - Analysis System by D. E. Delorey, AFGL-TR-81-0037).

The SC4-1 and SC4-2 data base formats are included in the appendix.

For the SC5, a routine was developed to unpack, edit, reformat, create auxiliary files and create a preprocess data base to be used by the analysis routines. One of the auxiliary files contains the magnetic pitch angle and sun angle for the parallel and perpendicular detectors. The data rate on this auxiliary file is sufficiently high to provide an interpolatable data set. Examples of the types of analysis routines used with the SC5 include contour displays of the velocity distribution at fixed distribution function values; contour integrations resulting in density, temperature and energy parameters; determination of particle flux, and determination of current. The SC5 data was used extensively in the environmental atlas.

Each SC5 agency tape contains data for a full day of operations. The 24 hour period runs from 0000: UT through 2400: UT.

The SC5 preprocess data base format is included in the appendix. Data base files have been successfully created for all digital data received from ESMC. Thus, the data base is complete for the entire first year of vehicle lifetime plus selected days of the second and third year of the lifetime.

A number of computer routines were developed which access the data base and provide science and housekeeping information. The following partial list provides examples of the types of routine which were developed:

a) retrieve counts information for all detectors, calculate magnetic pitch angle and sun angle for each spectra and produce listings;

b) calculate flux and/or distribution function along with magnetic and solar angle data - list and plot each spectra;

c) calculate and display contours of particle velocity as a function of magnetic pitch angle for fixed distribution function values;

d) integrate the distribution function data (with respect to velocity and magnetic pitch angle) over spins of the spacecraft to provide density, temperature and moments parameters;

e) retrieve counts, average and display results from the parallel detectors;

f) retrieve counts, calculate magnetic pitch angle and display these parameters as a function of time (done for both the parallel and perpendicular detectors);

g) calculate flux and magnetic pitch angle, bias the flux and display these parameters as a function of time;

h) retrieve housekeeping data, transform to engineering units - list and display the results;

i) perform up to a 3-Maxwellian analysis on a spectra by spectra basis thus providing density and temperature components of the plasma.

Relative to the UCSD SC9 particle detectors, all information pertaining to the instrument and analysis requirements were received through the Contract Monitor and/or the SC5 investigator.

The SC9 analyses use the agency tape as input. This multi-mode particle detector covers the energy range between a few eV and approximately 80 keV. The SC9 analysis routines which are used selectively provide listings and displays of the particle spectra. Typically, displays or listings of differential energy flux or distribution function as functions of time and energy are required for selected days and time periods. A routine was also developed to search the telemetry stream for commands to the instrument, decode the commands and produce a history of the commands over a one day period.

The magnetic field data on the agency tapes is used in the calculation of magnetic pitch angle. In addition, a routine was developed to extract the magnetic field data; optionally leave the reference frame as earth entered inertial (ECI) or map the data into either geocentric solar magnetospheric (GSM) or solar magnetic (SM); and produce displays and listings for selectable time periods.

2.2 Environmental Atlas Analysis Routines

For the environmental atlas, data bases of parameters derived from the SC5, SC10 and SC11 detectors were developed.

From the SC5 perpendicular detectors, full spectra and high energy moments data bases were created. Two anisotropy coefficient data bases were also created. The parallel detector channels were used in the creation of 10 minute local time averages of the flux for each channel. These data bases were created for over 100 days of data.

Relative to the SC10, digital tapes containing files referred to as the electric field, fourteen parameters and common mode data were sent from NASA/GSFC to AFGL. Approximately 70 days of data were received. These tapes required unpacking since data was written in a 32 bit integer format. Atlas requirements with respect to the common mode data included magnetic pitch angle determination, sun angle determination, and merging of ephemeris parameters. A charging determination routine performed the necessary analyses to determine frame potential. Since sporadic noise was present in the data, editing of the frame potential values was required. The charging data base consisted of the edited file. A merged file of SC5 moments parameters and the SC10 charging data base was also created.

A magnetic field data base wa also created. To accomplish this, the magnetic field (SC11) file was stripped from the SC9 agency tape. This file consisted of approximately 15 second averages of the triaxial field measurements. The averages were expressed in earth centered inertial (ECI) coordinates. The ECI measurements were mapped into the solar magnetic (SM) reference frame and a magnetic field data base of over 100 days created. The data base has the field components in both ECI and SM coordinates.

2.2.1 SC5 Moments Analysis

The full spectra and high energy analyses used in moments calculations differed only in the energy ranges used in the integrations.

Integrations were done (for each spin) to calculate the moments of the distribution function. A vehicle spin was defined as starting at a minimum magnetic pitch angle. Data from only the perpendicular detectors was used in the integrations. Ion and electron data were independently used.

Integrations resulted in the determination of the 4 prime parameters:

i) number density (particles/cm^3)

ii) number flux (particles/cm^2-sec)

iii) energy density (eV/cm^3)

iv) energy flux (eV/cm^2-sec)

The moments integrals were approximated as follows:

$$M_1 = \left[2 \sum_{j=1}^{m} \sum_{i=1}^{n} f_j(v_i)\, v_i^2\, \Delta v_i\, \Delta\psi_i\right] \times 10^{-15} = \text{Number Density}$$

$$M_2 = \left[2 \sum_{j=1}^{m} \sum_{i=1}^{n} f_j(v_i)\, v_i^3\, \Delta v_i\, \Delta\psi_j\right] \times 10^{-10} = \text{Number Flux}$$

$$M_3 = a_k \sum_{j=1}^{m} \sum_{i=1}^{n} f_j(v_i)\, v_i^4\, \Delta v_i\, \Delta\psi_j = \text{Energy Density}$$

$$a_k = \begin{cases} 1.03 \times 10^{-17} \text{ for ions} \\ 5.6 \times 10^{-21} \text{ for electrons} \end{cases}$$

and

$$M_4 = b_k \sum_{j=1}^{m} \sum_{i=1}^{n} f_j(v_i)\, v_i^5\, \Delta v_i\, \Delta\psi_j = \text{Energy Flux}$$

$$b_k = \begin{cases} 1.04 \times 10^{-12} \text{ for ions} \\ 5.68 \times 10^{-16} \text{ for electrons} \end{cases}$$

In the expressions for M_1, M_2, M_3 and M_4:

$$v = \text{velocity (km/sec)} \quad ,$$

$$f(v) = \text{distribution function (sec}^3/\text{km}^6) \quad ,$$

and

$$\psi = \text{magnetic pitch angle} \quad .$$

In the approximations, the subscript i is used in reference to energy channels and the subscript j refers to the spectra number within the spin. All integrations begin at the start of a spin and end with the last frame of a spin.

The $\Delta\psi_j$ are defined as follows:

$$\Delta\psi_j = \begin{cases} \alpha_{j+1} - \alpha_j & , \text{ for } j=1 \\ \dfrac{\alpha_{j+1} - \alpha_{j-1}}{2} & , \ 1<j<m \\ \alpha_j - \alpha_{j-1} & , \ j=m \end{cases}$$

where α_j was the central pitch angle for the j^{th} spectra within the spin.

Spectra occurring with a sun angle of less than 40° were deleted and interpolated for. A linear interpolation on f(v) as a function of time was used to replace the deleted spectra.

In particular, for each energy (velocity), the data pair $(t_j, f_j(v_i))$ immediately preceding the deletion and the data pair immediately following the deletion were used as the basis for the interpolation. An interpolated spectra was provided for each deleted spectra. The interpolated spectra were used in the integrations.

"Cleaned" spectra were used in the integrations and the cleaning process was done prior to any sun angle interpolation.

The process of providing cleaned spectra was defined as follows:

There are n distribution function values in each spectra $(f_1, f_2, \ldots, f_n)$; associated with each distribution function value is an energy $(E_1, E_2, \ldots, E_n)$.

i) If $f_j = 0$ for the first "k" values, set $f_1 = f_2 = f_3 = \ldots = f_{k+1}$. This provided distribution function values at the low energy end of the spectra.

ii) Any distribution function value of zero following the first non-zero value was obtained by the linear scheme.

$$\frac{\log f - \log f_i}{\log f_{i+1} - \log f_i} = \frac{E - E_i}{E_{i+1} - E_i}$$

The table of v, Δv, E and ΔE values used in the full spectra analysis is given below. For the high energy analysis the $LESA_1$ through $HESA_2$ channels were deleted. In the table, velocity values are in km/sec and energy information in eV.

Perpendicular Ions					Perpendicular Electrons				
Chan	v	Δv	E	ΔE	Chan	v	Δv	E	ΔE
$LESA_1$	170	60	148	102	$LESA_1$	6250	2400	110	70
$LESA_2$	260	100	340	240	$LESA_2$	9600	3400	260	180
$LESA_3$	400	150	840	525	$LESA_3$	16000	5000	620	370

Perpendicular Ions					Perpendicular Electrons				
Chan	v	Δv	E	ΔE	Chan	v	Δv	E	ΔE
$LESA_4$	590	210	1800	1160	$LESA_4$	24000	10000	1570	1130
$HESA_1$	880	320	4000	2700	HESA1	40000	14000	4400	2700
$HESA_2$	1370	580	9700	7500	$HESA_2$	55000	23000	9200	7100
$HESA_3$	2110	860	23000	16700	$HESA_3$	87000	30000	24000	15200
$HESA_4$	3260	1200	55000	39500	$HESA_4$	124000	46000	54000	43200
$\overline{\text{COINC0}}$	4815	1452	126000	70000	$\overline{\text{COINC2}}$	157000	42295	96000	78000
$\overline{\text{COINC1}}$	6018	1210	188000	75000	$\overline{\text{COINC3}}$	239000	37400	335000	117000
$\overline{\text{COINC2}}$	7289	1331	275000	100000	$\overline{\text{COINC4}}$	201650	33897	218000	115000
$\overline{\text{COINC3}}$	8653	1400	388000	125000					

In the computations, Differential Number flux $\left.\frac{d(F)}{dE}\right|_i$ and distribution function $f(E_i)$ at energy channel E_i were defined as follows:

i) $\left.\frac{d(F)}{dE}\right|_i = C_i \times K_i \times D_j$ (#/cm^2-sec-sr-eV))

where

$$C_i = \begin{cases} \text{counts}_i - \text{background counts, for LE ESA} \\ \text{counts}_i \quad \text{, for non LE ESA channels} \end{cases} ,$$

K_i was the proportionality factor and D_j was the degradation factor which was usually constant for each ESA detector and each day. Thus, for any given day, there were, in general, 4 values of D_j.

ii) $f(E_i) = \dfrac{\left.\frac{d(F)}{dE}\right|_i \times \lambda}{E_i}$ (sec^3/km^6)

where

$$\lambda = \begin{cases} .1617 \text{ for electrons} \\ 5.45 \times 10^5 \text{ for ions} \end{cases}$$

The format of the moments data base in in the appendix.

2.2.2 SC5 Parallel Detector Flux-Local Time Data Base

Using the data from the parallel detectors, averages of the flux were computed (for each channel) over each spin of the vehicle. The vehicle spin was defined by the same convention as used in the perpendicular detector analysis; i.e. the spin started at a point of minimum pitch angle and ran up to the next minimum. The time tag for the average was associated with the center of the spin. With the exception of the low energy ESA channels, a straight averaging was performed. For the low energy ESA channels, points were first deleted for which the flux was less than or equal to zero.

Counts were converted to differential number flux, $\left.\frac{d(F)}{dE}\right|_i$, at energy E_i by

$$\left.\frac{d(F)}{dE}\right|_i = C_i \times K_i \times D_j$$

where

$$C = \begin{cases} \text{counts}_i - \text{background}, & \text{for LE ESA} \\ \text{counts}_i & \text{for non LE ESA channels}, \end{cases}$$

K_i was the proportionality factor, and D_j was the degradation factor for each ESA detector and each day.

The spin averaged data was then averaged into 10 minute local time bins.

The format for this data base can be found in the appendix.

The table of channels and corresponding energies for the parallel detectors follows.

Parallel Electrons		Parallel Ions	
Channel	E (kev)	Channel	E (kev)
LE ESA 0	0.0	LE ESA 0	0.0
HE ESA 0	0.0	HE ESA 0	0.0
LE ESA 1	.112	LE ESA 1	.145
2	.271	2	.353
3	.679	3	.782

Parallel Electrons		Parallel Ions	
Channel	E (kev)	Channel	E (kev)
4	1.50	4	1.706
HE ESA 1	4.57	HE ESA 1	4.5
2	8.97	2	10.4
3	23.2	3	25.0
4	52.7	4	59.9
$\overline{\text{COINC}}$ 0	39	$\overline{\text{COINC}}$ 0	126
1	58	1	188
2	96	2	275
3	335	3	388
4	218	4	499
COINC 2	-	COINC 4	573
1	-	3	779
4	1040	2	1410
0	-	1	3060
3	-	0	6430

2.2.3 Anisotropy Coefficient Analysis

The SC5 data base was used as input to a routine developed to calculate anisotropy coefficients.

The anisotropy coefficient, A, is defined as

$$A = \begin{cases} \dfrac{F_{90}}{F_{45}} - 1 & \text{for } F_{45} \geq F_{90} \\ -\left(\dfrac{F_{45}}{F_{90}} - 1\right) & \text{for } F_{90} > F_{45} \end{cases}$$

where F_{90}, F_{45} are the differential number flux values at 90° and 45° magnetic pitch angle, respectively.

For each day that was processed, anisotropy coefficients were obtained for each electron and ion perpendicular detector channel. Approximately 119 days of data were used in the creation of the data base.

The constraints used in coefficient calculation were as follows:

a) points were considered only if the magnetic pitch angles were within 4° of 45° and 90°.

b) if the perpendicular detector readout at either the 45° or 90° point was also aligned with the sun, the flux values were replaced by the 90° point and 135° point on the decreasing pitch angle portion of the spin.

c) if the ESA detectors were off, the ESA anisotropy coefficients were set to -9999.

d) if the flux at both 45° and 90° was zero, the anisotropy coefficient was set to -9999.

The anisotropy coefficients were averaged into 10 minute local time bins for each day. In each 10 minute interval, the high and low values were rejected and an average and standard deviation computed if there were at least 3 points to be averaged. If there were less than 3 points, the average and standard deviation were set to -9999.

2.2.4 SC10 Analysis

The Common Mode data was received on 9 track tape in a 32 bit integer format. Thus, unpacking and decoding of the data was required. The rate for this data was one frame per second and each frame consisted of a UT time tag and three data samples. These samples (CM1-, CM2- and CM3-) represented voltage readouts at each of the sensitivity levels of the detector. From these three samples, a fourth value (CMTOTAL) was obtained from the following tests taken in sequence:

i. If $|CM3-| > 290$, then CMTOTAL = CM3-

ii. If $|CM3-| < 290$ and $|CM2-| > 14.5$, then CMTOTAL = CM2-

iii. If $|CM3-| < 290$ and $|CM2-| < 14.5$, then CMTOTAL = CM1-

The Common Mode file which was created contained the UT along with CM1-, CM2-, CM3- and CMTOTAL (which is frequently written as V_{10}). Auxiliary files necessary for attitude and ephemeris determination were copied from the agency tapes and stored off-line along with the common mode files.

The charging file was obtained by an analysis involving the angle between the sun and the SC10-2 boom along with the V_{10} data.

On a spin by spin basis (defining the start of each spin to be the frame of data at which the sun angle of the SC10-2 boom was at a minimum sun angle), two V_{10} values were selected. The conditions for selection were as follows:

i) All data was rejected for which the SC10-2 sun angle was less than 20° or greater than 160°.

ii) $V_{10_{max}}$ (or the frame potential) was taken to be the largest value of V_{10} between 20° and 40° sun angle on the side of the spin with increasing sun angles.

iii) $V_{10_{min}}$ was obtained by selecting the smallest value of V_{10} in the area between sun angles of 130° and 70° on the decreasing angle portion of the spin.

The charging data base was created by simply deleting periods of noise.

The format of the charging data base is contained in the appendix.

2.2.5 SC5/SC10 Merge

In order to provide the means of studying SC5 parameter variation as a function of frame potential, a merge of the SC5 final atlas data base and the charging data base was performed. The merge data base contains selected parameters from the SC5 final atlas data base, the frame potential from the charging data base and ephemeris information.

Merge data bases were created for:

i) all values of frame potential

ii) frame potential < 1.63

iii) frame potential > 10

iv) frame potential > 50

v) frame potential > 100 .

The conditions for merging a frame of SC5 data with a frame of SC10 data were as follows:

i) The SC5 frame closest in time to the SC10 frame was selected provided that the difference between the two times was less than one minute.

ii) If the conditions defined above were not satisfied,, no merge took place.

The merge data base format is in the appendix.

III S3-4 SATELLITE

3.0 Satellite/Payloads

The S3-4 satellite carried multiple AFGL payloads into polar. These payloads included a photometer, a UV and VUV spectrometer, a Cold Cathode Gauge (CCG), a Particle Flux Accumulator (PFA) and a Rotating Calibration Accelerometer (ROCA).

The SSDAS developed for this spacecraft was implemented resulting in the successful creation of data bases for full orbit operations.

The telemetry data from the vehicle was Pulse Code Modulated (PCM). Each mainframe consisted of 120 words, 8 bits per word. The ground command allowed for data to be acquired at two data rates (32kbps and 64kbps). In general, the mainframe word locations for the required designations were different for the two data rates. The 32kbps data rate was designated as Format A and the 64kbps data rate was designated as Format C. A masterframe (one readout of each subcommutated value) was made up of 32 frames in Format A and 64 frames in Format C. The telemetry system may be summarized as follows:

8 bits/word
120 words/mainframe
960 bits/mainframe

Format A		Format C
32K	BITS/SEC	64K
33.33	FRAMES/SEC	66.67
.03	SEC/FRAME	.015

Subcommutated Data (Format A)

MF Word No.	Subcom Length
25	8
26	8
82	32
83	32

Subcommutated Data (Format C)

MF Word No.	Subcom Length
42	64
43	64
69	16
70	16

The Vehicle Time Clock Word (VTCW) was made up of 24 bits which increment approximately every .2 seconds. The VTCW was located on MF 42, 43 and 44 in format A and MF 81, 82 and 83 in format C.

The tape recorder aboard the vehicle had a record capability of format A and 45 minutes in format C.

The instrumentation tapes were digitized in an agency tape (AT) format. Separate agency tapes were created for:

i) Spectrometer/Photometer
ii) PFA/CCG
iii) ROCA

Each orbit on the AT has four types of records; header record, scan record, event record and telemetry records. The header record contains information specific to the vehicle and orbit such as orbit number, date of orbit, GMT at the start and end of the pass and telemetry format type (A or C). The scan record contains information pertaining to areas of digitization dropout. The event record is specific to each agency tape type. For example, the event record for the CCG and PFA contains the times at which the extendable baffle is deployed. The telemetry records contain only the parameters designated for insertion into the agency tape data stream.

Each telemetry record contains masterframes of data with each masterframe starting at the mainframe containing subcommutator frame 1. By storing masterframes on each physical record, a maximum of information was stored on each magnetic tape. Further, by storing each masterframe in a consistent manner (starting at subcommutator level zero), the necessity of searching each file to find word locations of subcommutated data was removed.

Tracking data was received at AFGL/SUNY and this data was input to the SUNY ephemeris routines and coverage for each one month period (in 60 second increments) was generated on an output file. Parameters included on this file are altitude, longitude, geocentric latitude, geodetic latitude, velocity and local time.

The ephemeris file is used as an input to a routine, referred to as the B&L program, which calculates model magnetic parameters. A file of combined ephemeris and model magnetic parameters was created for each orbit, or orbital period, on which telemetry data was acquired. These files are called the B&L files.

As geophysical indices such as K_p and F10.7 CM solar flux were received, they were inserted into the INDICES file. Parameters contained on this file are necessary to the computation of the neutral atmospheric model parameters.

The INDICES file and the B&L file are input to the model atmosphere routine and the resulting file is called the Geophysical Support File (GSF). The GSF is identical in structure to the B&L file. Vacant words on the B&L file were filled with such model parameters as temperature, pressure, mass density and constituent densities for O, O_2, N_2, H_e, H and A_r. The atmospheric model used was Jacchia'71.

Processing routines use as input the agency tapes and either the B&L or GSF files. From these routines, plots and listings were generated as required and data bases created. Processing routines were developed for the spectrometer, photometer, PFA, CCG, and ROCA.

Telemetry data for full orbit operations was recorded only in Format A. Data bases were completed for all full orbit operations of the spectrometer, photometer and PFA. The CCG data was processed on a selective basis. All full orbit ROCA orbits which were bracketed by bias operations (orbits on which the detector was rotated 90° from the velocity vector) were processed.

3.1 Photometer

This instrument used a photomultiplier as a detector over 4 broad wavelength ranges. The ranges were selectable. Field of view and associated sensitivity changes were provided by selecting one of four apertures. The counting period is 10_{MS}. Any of the 4 wavelengths and 4 apertures could be commanded. There is also an automatic filter change mode. The aperture was normally small during daytime and large for nighttime operations.

The photometer telemetry is summarized below:

DESIG	DESC.	BITS	FORMAT A MF	RATE	FORMAT C MF	RATE
K102	Photometer HV	8	97	33	31	66
K105	Photometer +5V Logic	8	51	33	91	66
K107	Photometer Detector T Temp	8	71	33	111	66
K122	Photometer Power Supply Temp	4	66(4LSBS)	33	39(4LSBS)	66
K150-K151	Photometer VUV Data	16	5,45,85	100	49,109	133 1/3
K160-K161	Photometer Aperture/ Filter Status		82(Subcom 24)	1	42(Subcom 24)	1

The 16 bit K150 serial-digital readout is expressed as follows:

$$\begin{array}{ll} \text{MSB} & \qquad\qquad \text{LSB} \\ \underbrace{\boxed{1 \longrightarrow 12}}_{\text{Photometer Photomultiplier Counts (G. Tube Counts)}} & \underbrace{\boxed{13 \longrightarrow 16}}_{\text{Unused}} \end{array}$$

The 16 bit K160 serial-digital photometer aperture/filter status word is represented as follows:

MSB LSB

1 → 3	4 → 6	7 → 16
Filter Position Status	Aperture Position Status	Unused

The filter position bit relationship was:

Position	Bits	Remarks
1	1 1 1	Open (no filter)
2	0 1 1	1216A
3	1 0 0	1340A
4	1 0 1	1550A
5	1 1 0	1850A

For the aperture:

Position	Bits	Remarks
1	0 1 0	Closed
2	0 1 1	Largest Aperture
3	1 1 0	
4	1 1 1	
5	1 0 1	Smallest Aperture

The data base creation routine created as a standard output a time history display of radiance data along with selected ephemeris and magnetic parameters. Radiance was computed using formulas involving filter position and telemetry data rate.

3.2 Spectrometer

The spectrometer had an ultraviolet unit and a vacuum ultraviolet unit. Photomultiplier tubes were used as detectors and both ranges are scanned simultaneously by diffraction gratings rotating on a shaft common to both units. Background intensity was obtained as a function of wavelength. Resolution and sensitivity were controlled by selecting one combination from a group of fixed width slits.

The approximate wavelength ranges for the VUV and UV detectors were 1070Å-1930Å and 1610Å-2900Å, respectively.

A total range of 4000 steps was required to cover the spectrum. There was a 5 MS counting period at each step. This scanning occurred whenever the spectrometer is on.

The telemetry word information is summarized below:

			FORMAT A		FORMAT C	
DESIG	DESC.	BITS	MF	RATE	MF	RATE
K101	Spectrometer G. Tube Temp (vuv)	8	11	33	8	66
K103	Spectrometer F. Tube HV (uv)	8	31	33	51	66
K104	Spectrometer G. Tube HV (vuv)	8	41	33	48	66
K106	Spectrometer +5V Logic	8	7	33	41	66
K121	Spectrometer F. Tube Temp (uv)	4	66 (4MSB'S)	33	39 (4MSB'S)	66
K123	Spectrometer Power Supply Temp	4	106	33	29	66
K140-K144	Spectrometer Data	36	12,32,52, 72,92,102	200	20,60, 100	200

The 36 bit serial-digital data was broken down as follows:

1 → 12	13 → 24	25 → 32	33	34 → 36
UV Photomultiplier Counts (F. Tube)	VUV Photomultiplier Counts (G. Tube)	Wavelength Counter	Un-used	Slit Data

Slit Information (3 bits):

SLIT SIZE

Mode	Bits	VUV	UV
1	1 0 1	Closed	Closed
2	0 0 1	1A	1A
3	1 0 0	5A	1A
4	0 0 0	5A	5A
5	1 1 0	25A	5A
6	0 1 0	25A	25A

Standard inputs to the spectrometer data base routine were the agency tape and the GSF data.

The routine:

1) converted the wavelength counter to actual wavelength in angstroms,

2) produced displays of spectra averaged over 20 scans,

3) performed averaging procedures, extracted detector counts at fixed wavelengths and produced various forms of time history displays at the fixed wavelengths,

4) created the data base file.

Follow-on analysis routines were developed which use the data base as input. An example of this type of routine is the zonal averaging routine. The routine was designed to produce displays of average spectra over defined sets of positional conditions. Resulting displays exhibit midday background; night tropical airglow; northern and southern hemisphere aurora.

3.3 Particle Flux Accumulator (PFA)

The PFA measured atmosphereric neutral density and its spatial and temporal variations.

The PFA consists of a sensor, electronics unit and extendable baffle.

The sensor is an ionization gauge which measures internal gas pressure which can be related to ambient atmospheric density.

A baffle mechanism was included as part of the payload. When initiated, the baffle sequence included a full extension and retraction. The primary data occurred while the baffle was retracted.

DESIG	DESC.	FORMAT A BITS	MF	RATE	FORMAT C MF	RATE
K201	Density Data	8	67	33	28,68,108	200
K202	Electronics Temp	8	91	33	44	66
K203	Sensor HV	8	101	33	84	66
K204	Baffle Status	8	111	33	10	66
K211	Range	8	57	33	11,71	133
K221	Sensor Temp	4	106(4LS BS)	33	29(4LS BS)	66
K231	Gauge Open/Closed	1	21(Bit 1)	33	89(Bit 2)	66

Briefly, the data base routine:

1) Converted PCM counts to current and then to gauge pressure.

2) Computed ambient pressure, P_A, from the formula

$$P_A = \frac{P_g}{R(S,D,\alpha)} \sqrt{\frac{TM}{300}}$$

where $R(S,D,\alpha)$ is a calibration table and T_M is model atmospheric temperature at altitude.

The value of attack angle, α, was fixed at a constant for each orbit,

$$S = \frac{V}{\sqrt{2R_M T_M/M}}$$

where V=velocity (M/S), R_M=8.317×10^3, and M=most probable mass.

3) Computed ambient density, P, from the formula:

$$P = \frac{133.37 \times P_A \times M}{8.317 \times T_M} \times 10^{-6}$$

4) Created time history displays of density data along with ephemeris and magnetic parameters.

5) Created the data base file.

3.4 Rotating Calibration Accelerometer (ROCA)

The ROCA is a single axis electrostatic accelerometer which could be rotated 90° (parallel or perpendicular to the velocity vector). The instrument measured aerodynamic drag accelerations which are directly proportional to atmospheric density. Normal operating position is parallel to the velocity vector. The perpendicular position provides instrument bias information which was used in computing the total acceleration.

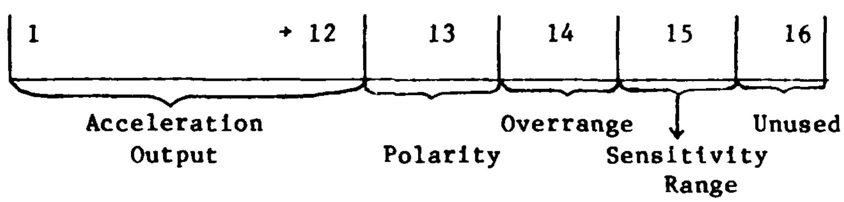
The ROCA provided measurements down to 10^{-7}g. The instrument has 2 ranges (A and B). The probe turns on in range A (for approximately 20 secs) to allow centering of the proof mass then switches to its normal operating range (range B). High accelerations cause overranging which result in the automatic change to range A for 20 seconds. It will then automatically return to range B for 2 seconds. This procedure continues automatically whenever overranging occurs. Sample time for the instrument is .25 seconds. The sensitive axis was rotated to a position perpendicular to the velocity vector at selected intervals. Orbits on which the rotation occurred were referred to as bias orbits since the purpose of the rotation was the determination of instrument bias.

The ROCA Telemetry Words are summarized as follows:

			FORMAT A		FORMAT C	
DESIG	DESC.	BITS	MF	RATE	MF	RATE
K210	Temperature	8	37	33	90	66
K223	Position Status	4	65(4LS BS)	33	119(4LS BS)	66
K240-K241	Acceleration Output	16	25/26 Subcom 1*	4	69/70 Subcom 1(**)	4

(*) Subcom is 8 words; (**) Subcom is 16 words

The ROCA 16 bit digital readout is decoded as follows:



For the polarity bit, 0 = positive, 1 = negative. If the polarity bit is negative, 4096 must be subtracted from the acceleration output and the sign changed to a negative.

The overrange bit is normally 0 but becomes 1 when the instrument is in overrange.

The sensitivity bit indicates instrument range: 0=Range A; 1=Range B.

For the ROCA, the non-rotation and bias orbits are treated separately although similar techniques were applied to both types of data acquisition.

First, the counts data was filtered using a standard 50-100 second filter. For the bias orbits, which were scattered throughout instrument lifetime, detector counts were fit as a function of detector temperature. A lifetime profile of the bias fit coefficients was thus derived.

When processing the non-bias, or standard, orbits:

1) the bias fit coefficients were interpolated for as a function of orbit number,

2) selected GSF data was merged,

3) the data in the area of apogee (which is the low drag area of the orbit) was used in conjunction with the model atmospheric density to refine the bias,

4) instrument temperature was fit as a function of time,

5) instrument counts were converted to micro-g's by means of the temperature dependent scale factors,

6) drag acceleration was computed,

7) neutral density was computed from formulae involving drag acceleration, vehicle mass, velocity, drag coefficient and area,

8) density displays as a function of altitude were produced,

9) the density data base which included selected ephemeris and magnetic parameters was created.

Data base output was created for all Format A full orbit operations which were bracketed by bias orbits.

IV P78-1 SATELLITE

4.0 Satellite/Payload

The P78-1 satellite carried the High Latitude Particle Spectrometer (CRL-251) into sun-synchronous orbit. The near circular orbit (approximately 590 km) had a period of 96 minutes. The spin axis of the spacecraft was normal to the orbital plane and a nominal spin rate of 11 rpm was maintained.

The spacecraft telemetry system (PCM) was capable of operation at 2 data rates, 64 kbps and 32 kbps. The CRL-251 was operated only in the 32 kbps mode. The specifics of the 32 kbps system can be summarized as follows:

128	words/mainframe
8	bits/word
1024	bits/mainframe
31.25	frames/second
.032	seconds/frame
2.048	seconds/masterframe .

There were 3 tape recorders aboard the satellite. The CRL-251 data was primarily recorded using tape recorders A and B.

The objective of the CRL 251 experiment is to gather electron data with particular interest being rendered to the auroral zones during magnetically active periods.

The instrument measures particle fluxes precipitating from high latitude polar caps, auroral zones and the plasma pause.

The payload consists of four electrostatic analyzers (ESA). There are two low and two high energy analyzers. Each ESA produces an 8 point spectrum. The low and high energy analyzers are paired and mounted 90° apart in the spin plane. Thus, a 16 point spectra is produced simultaneously in each of 2 orthogonal look directions. A spectrum is acquired every 256 msec.

The analyzers are of curved cylindrical plate design with balanced positive and negative deflection voltages.

The electrons are collected at discrete energies ranging between 50 eV and 20 keV. The two sets of curved parallel plates have a time sequenced variable electrostatic field which deflects the electrons towards the channeltron electron multipliers (which are used as detectors). One set of plates collects electrons in the 50 eV to 1 keV energy range while the other set of plates accumulates 1 keV to 20 keV electrons. There are 8 energy bins for each set of plates and thus a complete spectra consists of 16 energy bins.

Eight complete spectra are readout every masterframe (64 mainfrmes; 2.048 seconds). The spectra data is a digital readout and four readouts are provided on each mainframe. These values are located on mainframe words 91, 115, 116 and 123. Data from instrument 1 is readout on words 91 and 115. The instrument 2 data is located on mainframe words 116 and 123.

The electrons are counted at each energy level for 32 msec (one mainframe). The eight bit digital readout is encoded with a 5 bit mantissa and a 3 bit exponent. The eight bit readout is converted to counts as follows:

MSB LSB

$$\underbrace{\boxed{1}\boxed{2}\boxed{3}\boxed{4}\boxed{5}}_{x}\underbrace{\boxed{6}\boxed{7}\boxed{8}}_{y}$$

The instrument was nominally operated for 20 orbits per week although more extensive turn-ons occurred during periods of high geomagnetic activity.

Tape recorder playback data was recorded onto instrumentation tapes at AFSCF remote tracking stations.

4.1 CRL-251 Data Base/Analysis

Instrumentation tapes were digitized in an agency tape form by ESMC. Each 9 track digital tape contained 5 files of data: header, scan, event, estimation module (EM) and telemetry data. (Nearly all of the CRL-251 data for the first year of vehicle lifetime was digitized by ESMC.) Procedures similar to those employed for P78-2 and S3-4 were used in defining the agency tape structure.

In fact, several elements of commonality existed between the processing and analysis requirements for the CRL-251 and the SCATHA SC5 data. Routines developed for one detector were adapted for the other wherever possible. Techniques developed for the SSDAS for S3-4 also had application with the P78-1 system. Ephemeris and B&L data was created on a one file per instrument turn-on basis. The files were created with versions of the S3-4 routines.

Attitude requirements (magnetic pitch angle attack angle data and sun angle data) were satisfied through combinations of the output module (OM) line-of-sight determination routine and individual modules for computing and manipulat-the appropriate vectors.

The data base routine was structured to input the agency tape and B&L file; merge ephemeris parameters; calculate attitudinal parameters; convert the telemetry data to differential number flux; compute and display total number flux, total energy flux and average energy; and write the data base file.

All digital data received from ESMC was successfully processed and the data base created (the P78-1 file format is located in the appendix).

Several data base analysis routines have been successfully developed and employed. Examples of such routines include:

a) calculation and display of fixed distribution function contours in a polar coordinate representation;

b) 3-D displays of flux as functions of energy and magnetic pitch angle;

c) retrieval and display of differential flux as a function of energy for selected time periods;

d) determination of the distribution function moments (number density, number flux, energy density and energy flux) over spins of the spacecraft.

APPENDIX A

SCATHA SC4-1

Data Base Format

SC4-1 Data Base - Header Record

Word #		
0.1	Word count (Integer -10)	
0.2	Group count (Integer =1)	
1	bbbbb C4-1	
2	Day of year	Alphanumeric
3	Month	F
4	Day	F
5	Year (last 2 digits of 19xx)	F
6	Start time of tape (from ETR) sec	F
7	End time of tape (from ETR) sec	F
8		
9	Vacant	
10		

SC4-1 Data Records

0.1 Word count (13)
0.2 Group count (32) (32 frames/record; 2 masterframes)

Word	Bits	Description
1	1-60	GMT (sec)
2	1-60	Altitude (km)
3	1-36	The 32 bits from mainframe words 38, 39, 40 and 41 (right adjusted) from even frame no.
	37-60	Same TLM words as above from succeeding frame
4	1-12	
	13-24	Gun cap deployment flag (bit 23) and beam on/off flag (bit 24) (*)
	25-36	Beam current flags (right adjusted) (*)
	37-48	Beam energy flags (right adjusted) (*)
	49-60	Beam duty cycle flat (bit 60) (*)
5	1-12	Beam focus flags (right adjusted) (*)
	13-24	D4001 (from MF 21)
	25-36	D4002 (from MF 53)
	37-48	D4001 (from MF 85)
	49-60	D4002 (from MF 117)
	1-12	D4001 (from MF 21)
.		.
.		.
.		.
11	25-36	D4002 (from MF 117)
	37-48	HV Monitor (*)
	49-60	LV Monitor 1 (*)
12	1-12	LV Monitor 2 (*)
	13-24	Gun cap current monitor (*)
	25-36	Temperature monitor (*)
	37-48	Geodetic latitude × 10 (MSB=1 if latitude negative)
	49-60	Geocentric longitude × 10

Word	Bits	Description
13	1-12	Local time in hours and minutes (e.q. $22^{H}15^{M}$=2215)
	13-24	SC4-1 magnetic pitch angle at GMT tag for this frame
	25-36	SC4-1 magnetic pitch angle at GMT + .5 sec
	37-48	SC4-1 magnetic pitch angle at GMT + 1. sec
	49-60	Vacant

Word order of word 1 thru word 13 repeats for next 31 seconds.
(418 60-bit words/record)

(*)Indicates subcommutated value; if no readout for this 1 second interval, MSB (of the 12 bits) will be set to 1 to indicate dummy fill.

APPENDIX B

SCATHA SC4-2

Data Base Format

SC4-2 Data Base - Header Record for Data File

0.1 Word count (10)

0.2 Group count (1)

1	bbbbbSC4-2	Alphanumeric
2	Day of year	F
3	Month	F
4	Day	F
5	Year (last 2 digits of 19xx)	F
6	Start time of tape (from ETR) - sec	F
7	End time of tape (from ETR) - sec	F
8		
9	Vacant	
10		

SC4-2 Data Records

0.1 Word count (18)

0.2 Group count (16)

Word	Bits	Description
1	1-60	GMT (sec)
2	1-60	Altitude (km)
3	1-12	Bit 11 = blow off cover flag; Bit 12 = neutralizer bias polarity flag (*)
	13-48	Command status (MF 38,39,40,41) right adjusted
	49-60	Command status (MF 38,39,40,41) right adjusted
4	1-24	
	25-36	$D4008_1$ Beam current monitor values (counts) (16 pps)
	37-48	$D4008_2$
	.	
	.	
	.	
7	25-36	$D4008_{16}$
	37-48	D4011 - Beam voltage Mon. (*)
	49-60	D4012 - Disch. current Mon.
8	1-12	D4013 - Discharge voltage Mon.
	13-24	D4014 - Keeper voltage Mon. (*)
	25-36	D4015 - Keeper HV monitor (*)
	37-48	D4016 - Keeper LV monitor
	49-60	D4017 - Cathode heater current Mon.
9	1-12	D4018 - Accel. current Mon. (*)
	13-24	D4019 - Decel. current Mon. (*)
	25-36	D4020 - Neut. heater current Mon. (*)
	37-48	D4021 - Neut. bias voltage Mon. (*)
	49-60	$D4009_1$ Neutralizer Emission monitors (16 pps)
10	1-12	$D4009_2$
	.	.
	.	.
	.	.
12	49-60	$D4009_{16}$

Word	Bits	Description
13	1-12	$D4010_1$ } SPIBS net current monitor (16 pps)
	13-24	$D4010_2$
	.	.
	.	.
	.	.
16	1-12	$D4010_{16}$
	13-24	D4022 - Tank pressure monitor (*)
	25-36	D4023 - Power processor temp. Mon. (*)
	37-48	D4024 - D4024 - PPA AC Inv. current monitor (*)
	49-60	D4025 - PPA AC Inv. voltage Mon. (*)
17	1-12	Geodetic latitude × 10 (MSB = 1 if negative)
	13-24	Geocentric longitude × 10
	25-36	Local time (hours and min., e.q. 22^H15^M = 2215)
	37-48	SC4-2 magnetic pitch angle at GMT tag for this frame
	49-60	SC4-2 magnetic pitch angle at GMT + .5 sec
18	1-12	SC4-2 magnetic pitch angle at GMT + 1. sec
	13-60	Vacant

Words 1 through 18 will repeat 15 times in each record (16 seconds of data/record)

(*)Subcommutated values; if no readout for this one second interval, MSB will be set to 1 to indicate dummy fill.

APPENDIX C

SCATHA SC5 Preprocess File Format

SC5 Preprocess File - Header Record Format

0.1	Integer (number of words in record; 10)	
0.2	Integer (1)	
1	bSC5PREPRO	A
2	bbbbSCATHA	A
3	Month of year	F
4	Day of month	F
5	Year (last 2 digits of 19xx)	F
6	Day of year	F
7	Start time (from AT header) - sec.	F
8	End time (from AT header) - sec.	F
9	Vacant	
10	Vacant	

SC5 Preprocess File - Data Record Formats
(each record contains a masterframe)

0.1 Word Count (integer) - number of words/group (31)
0.2 Group Count (integer) - number of groups/record (16)

Word	Bits	Description	
1	All	GMT (seconds) (at start of mainframe)	
2		altitude	
3		L-shell	
4		magnetic local time (floating point hours)	
5		geocentric latitude	
6		geocentric longitude	
7		geomagnetic longitude	
8		geomagnetic latitude	
9		invariant latitude	
10		vacant	
11	vacant		
12	1-12 13-24 49-60	low energy ESA (electrons) counts ($\perp$) E=3MSB's; M=9 LSB's (for normal ops, bits 1-12 have counts for energy channel 0; 13-24 for channel 1...)	(E4503)
13	1-12 13-24 ⋮ 49-60	High energy ESA (electrons) counts ($\perp$)	(E4503)
14	1-12 13-24 ⋮ 49-60	SSS $\overline{\text{COINC}}$ counts (electrons; $\perp$)	(E4511)
15	1-12 13-24 ⋮ 49-60	SSS COINC counts (electrons, $\perp$)	(E4513)
16	1-12 13-24 ⋮ 49-60	Low energy ESA (ions); $\perp$	(E4507)

Word	Bits	Description	
17.	1-12 13-24 49-60	Hi Energy ESA (ions) ; $\perp$	(E4509)
18.	1-12 13-24 49-60	SSS $\overline{\text{COINC}}$ (ions) ; $\perp$	(E4515)
19.	1-12 13-24 49-60	SSS COINC (ions) ; $\perp$	(E4517)
20.	1-12 13-24 49-60	Lo Energy ESA electrons ; $\parallel$	(E4504)
21.	1-12 49-60	Hi Energy ESA electrons; $\parallel$	(E4506)
22.	1-12 49-60	SSS $\overline{\text{COINC}}$ electrons; $\parallel$	(E4512)
23.	1-12 49-60	SSS COINC electrons ; $\parallel$	(E4514)
24.	1-12 49-60	Lo Energy ESA ; ions ; $\parallel$	(E4508)
25.	1-12 49-60	Hi Energy ESA ; ions $\parallel$	(E4510)
26.	1-12 49-60	SSS $\overline{\text{COINC}}$ - ions ; $\parallel$	(E4516)
27.	1-12 49-60	SSS COINC - ions ; $\parallel$	(E4518)
28.	1-12	ESA energy channel_1	
	13-24	ESA energy channel_2	
	25-36	ESA energy channel_3	
	37-48	ESA energy channel_4	
	49-60	ESA energy channel_5	
29.	1-12	SSS energy channel_1	
	13-24	SSS energy channel_2	
	25-36	SSS energy channel_3	
	37-48	SSS energy channel_4	
	49-60	SSS energy channel_5	

Words	Bits	Description	
30.	vacant		
31.	vacant		
32-62.	Repeat structure of words 1-31 for the next second		
63-93.	Repeat structure of words 1-31 for the next second		
435-465	Repeat structure of words 1-31 for the next second		
466-496	Repeat structure of words 1-31 for the next second		
497	1-12	+3500V Monitor Counts	(E4001)
	13-24	+500V Monitor Counts	(E4002)
	25-36	+2500V Monitor Counts	(E4003)
	37-48	-500V Monitor Counts	(E4004)
	49-60	-30V Monitor Counts	(E4005)
498	1-12	Electron Bias voltage counts	(E4006)
	13-24	+15V Monitor Counts	(E4007)
	25-36	+10V Monitor Counts	(E4008)
	37-48	-5V Monitor Counts	(E4009)
	49-56	-10V Monitor Counts	(E4010)
499	1-12	HE ESA sweep voltage Monitor Counts	(E4011)
	13-24	LE ESA sweep voltage Monitor Counts	(E4012)
	25-36	P-SSD Bias voltage Monitor Counts	(E4013)
	37-48	P-SSD Bias voltage Monitor Counts	(E4014)
	49-60	DC-DC Converter Temp. Monitor Counts	(E4015)
500	1-12	SSS Temp. Monitor Counts	(E4016)
	13-24	SSS Temp. Monitor Counts	(E4017)
	25-36	Vacant	
	37-48		
	49-60		

(Each record has 502 words - (500 information words plus the two counts words;) 16 seconds of data were be stored in each record).

APPENDIX D

SC5 Environmental Atlas Moments
Data Base Format

Word	Description		
1	Alphanumeric	SC5bFAbDBb	
2	Year		
3	Month		
4	Day		
5	Minimum pitch angle from spin (α_{min})		
6	Pitch angle value closest to 180° (α_{max})		
7	GMT (seconds)		
8	Day of year		
9	Number density (#/cm^3) electrons		(N_H)
10	Vacant		
11			
12	Number density (#/cm^3) ions		(N_H)
13	Vacant		
14			
15	Energy density, electrons	(ev/cm^3)	
16	Energy density, ions	(ev/cm^3)	
17	Energy flux, electrons	(ev/cm^2-sec)	
18	Energy flux, ions	(ev/cm^2-sec)	
19	Number flux, electrons	(#/cm^2-sec)	
20	Number flux, ions	(#/cm^2-sec)	
21-26	Vacant		
27	T_{rms_H} (kev) electrons		
28	T_{rms_H} (kev) ions		
29	LT (hours)		
30	Alt (km)		
31	R_e (satellite altitude - earth radii)		
32	Latitude (deg)		
33	L-shell		
34	Magnetic time (hours)		
35	Radius (magnetic) - earth radii		
36	Magnetic latitude		
37	Magnetic longitude		
38	$K_p \times 3$		

Word	Description
39	SM latitude (deg)
40	SM local time (hrs)
41	GSM latitude (deg)
42	GSM local time (hrs)
43-50	Vacant
51	Total number density (#/cm^3) electrons
52	2-Maxwellian density n_1 (#/cm^3) electrons
53	2-Maxwellian density n_2 (#/cm^3) electrons
54	Total number density (#/cm^3) ions
55	2-Maxwellian density n_1 (#/cm^3) ions
56	2-Maxwellian density n_2 (#/cm^3) ions
57	Energy density (ev/cm^3) electrons
58	Energy density (ev/cm^3) ions
59	Energy flux (ev/cm^2-sec) electrons
60	Energy flux (ev/cm^2-sec) ions
61	Number flux (#/cm^2-sec) electrons
62	Number flux (#/cm^2-sec) ions
63	2-Maxwellian temperature, T_1 (kev) - electrons
64	2-Maxwellian temperature, T_2 (kev) - electrons
65	2-Maxwellian temperature, T_1 (kev) - ions
66	2-Maxwellian temperature, T_2 (kev) - ions
67	T_{avg} (ev) electrons
68	T_{avg} (ev) ions
69	T_{rms} (ev) electrons
70	T_{rms} (ev) ions
71-78	Vacant

In this data base, words 9 through 28 were calculated by the use of the High Energy analysis. Words 51 through 78 were calculated by means of the full spectra analysis.

APPENDIX E

SC5 Parallel Detector Flux-Local Time Data Base Format

Average Flux Data File

Header Record

0.1	Integer (10) - number of words/group	
0.2	Integer (1) - 1	
1	SC5AVGFLUX	(A)
2	Year-Day (e.g. 79087.)	(F)
3	Year (last 2 digits of 19xx)	(F)
4	Month	(F)
5	Day of month	(F)
6-10	Vacant	

Data Records

0.1	Integer (37) - Number of words/group
0.2	Integer (≤13) - Number of groups/record
1	GMT (seconds) at center of spin
2	LE ESA 1
3	2
4	3
5	4
6	HE ESA 1
7	2
8	3
9	4
10	COINC 0
11	1
12	2
13	3
14	4
15	COINC 2
16	1
17	4
18	0
19	3

$\left.\right\}$ Average flux for electron detectors (parallel)

Data Records (Cont.)

20	LE ESA 1	
21	2	
22	3	
23	4	
24	HE ESA 1	
25	2	
26	3	Average flux for
27	4	ion detectors (parallel)
28	COINC 0	
29	1	
30	2	
31	3	
32	4	
33	COINC 4	
34	3	
35	2	
36	1	
37	0	

The order for words 1 through 37 were then repeated to produce records containing up to 13 groups.

One file per day was created.

APPENDIX F

SC10 Charging Data Base
Format

SC10 Charging Data Base

Header Record

Word #	Description	Format
1	bbbbbb SC10	A
2	COMMONMODE	A
3	Year	F
4	Day	F
5	bbCHARGING	A

Data Records

Word #	Description	
1	Time of V_{10} max (T_{max})	
2	V_{10} max	
3	Sun angle at T_{max}	
4	Pitch angle at T_{max}	
5	Time of V_{10} min (T_{min})	
6	V_{10} min	
7	Sun angle at T_{min}	
8	Pitch angle at T_{min}	
9	Local time (hours)	Ephemeris parameters calculated at time = T_{max}
10	Altitude (km)	
11	Latitade (degrees)	
12	L-shell	
13	Magnetic time (hours)	
14	Radius (magnetic) - earth radii)	
15	Magnetic latitude (deg)	
16	Magnetic longitude (deg)	
17	SM latitude (deg)	
18	SM local time (hrs)	
19	GSM latitude (deg)	
20	GSM local time (hours)	
21	$K_p \times 3$	

APPENDIX G

SC5/SC10 Merge

Data Base Format

Header Record

Word #	
1	SC5SC10ALL
2	Year
3	Day

Data Records

Word #	Description	
1	Time of V_{10} max (UT seconds)	
2	V_{10} max (volts)	
3	LT (hours)	
4	Altitude (km)	
5	Latitude (deg)	
6	L-shell (ER)	
7	Magnetic time (hrs)	
8	Magnetic radius (ER)	From SC10 data base
9	Magnetic latitude (deg)	
10	Magnetic longitude (deg)	
11	SM latitude (deg)	
12	SM local time (hrs)	
13	GSM latitude	
14	GSM local time	
15	$K_p \times 3$	
16	Number density (#/cm^3) electrons - high energy (N_H)	
17	Number density (#/cm^3) ions - high energy (N_H)	
18	Energy density (ev/cm^3) electrons - high energy (ED_H)	
19	Energy density (ev/cm^3) ions - high energy (ED_H)	
20	Energy flux (ev/cm^2-sec) electrons - high energy (EF_H)	
21	Energy flux (ev/cm^2-sec) ion - high energy (EF_H)	
22	Number flux (#/cm^2-sec) electrons - (NF_H)	
23	Number flux (#/cm^2-sec) ions - (NF_H)	
24	T_{RMS} (kev) - electrons - high energy (T_{RMS_H})	

Word	Description
25	T_{RMS} (kev) - ions - high energy (T_{RMS_H})
26	Total number density (#/cm^3) - electrons (N_T)
27	2-Maxwellian density (#/cm^3) - electrons (n_1)
28	2-Maxwellian density (#/cm^3) - electrons (n_2)
29	Total number density (#/cm^3) - ions (N_T)
30	2-Maxwellian density (#/cm^3) - ions (n_1)
31	2-Maxwellian density (#/cm^3) - ions (n_2)
32	Energy density (ev/cm^3) - electrons (ED_T)
33	Energy density (ev/cm^3) - ions (ED_T)
34	Energy flux (ev/cm^2-sec) - electrons (EF_T)
35	Energy flux (ev/cm^2-sec) - ions (EF_T)
36	Number flux (#/cm^2-sec) - electrons (NF_T)
37	Number flux (#/cm^2-sec) - ions (NF_T)
38	2-Maxwellian temperature T_1 (kev) - electrons T_1
39	2-Maxwellian temperature T_2 (kev) - electrons T_2
40	2-Maxwellian temperature T_1 (kev) - ions T_1
41	2-Maxellian temperature T_2 (kev) - ions T_2

APPENDIX H

Anisotropy Coefficient
Data Base Format

Anisotropy Data Base

Header Record

Word #	Description	
1	Anisotropy	(A)
2	10MINLTAVG	(A)
3	Year/day (e.q. 79089)	F
4	Year	
5	Month	
6	Day of month	
7-10		

Data Records

Word #	Description		
1	ut at center of averaging interval		
2	$\bar{A}$	$LESA_1$	Electron Data
3	σ		
4	$\bar{A}$	$LESA_2$	
5	σ		
6	A	$LESA_3$	
7	σ		
8	A	$LESA_4$	
9	σ		
10	A	$HESA_1$	
11	σ		
12	A	$HESA_2$	
13	σ		
14	A	$HESA_3$	
15	σ		

Word #	Description		
16	A	$HESA_4$	Electron Data
17	σ		
18	A	$\overline{\text{COINC}}$ 0	
19	σ		
20	A	$\overline{\text{COINC}}$ 1	
21	σ		
22	A	$\overline{\text{COINC}}$ 2	
23	σ		
24	A	$\overline{\text{COINC}}$ 3	
25	σ		
26	A	$\overline{\text{COINC}}$ 4	
27	σ		
28	A	COINC 0	
29	σ		
30	A	COINC 1	
31	σ		
32	A	COINC 2	
33	σ		
34	A	COINC 3	
35	σ		
36	A	COINC 4	
37	σ		
38	A	LESA 1	Ion Data
39	σ		
40	A	LESA 2	
41	σ		

Word #		Description	
42	A	LESA 3	Ion Data
43	σ		
44	A	LESA 4	
45	σ		
46	A	HESA 1	
47	σ		
48	A	HESA 2	
49	σ		
50	A	HESA 3	
51	σ		
52	A	HESA 4	
53	σ		
54	A	$\overline{\text{COINC}}$ 0	
55	σ		
56	A	$\overline{\text{COINC}}$ 1	
57	σ		
58	A	$\overline{\text{COINC}}$ 2	
59	σ		
60	A	$\overline{\text{COINC}}$ 3	
61	σ		
62	A	$\overline{\text{COINC}}$ 4	
63	σ		
64	A	COINC 0	
65	σ		

Word #	Description		
66	A	COINC 1	Ion Data
67	σ		
68	A	COINC 2	
69	σ		
70	A	COINC 3	
71	σ		
72	A	COINC 4	
73	σ		
74	LT (minutes) at center of averaging interval (e.q., 5.10)		
75	LT (hours) e.q. 20.5		Ephemeris parameters calculated at ut time tag.
76	Alt (km)		
77	R_e (earth radii)		
78	Latitude (deg)		
79	L-shell		
80	Magnetic time (hrs)		
81	Radius (magnetic)		
82	Magnetic lat (deg)		
83	Magnetic long (deg)		
84	$K_p \times 3$		
85	SM lat (deg)		
86	SM local time (hrs)		
87	GSM lat (deg)		
88	GSM local time (hrs)		

For anisotropy coefficients and standard deviations, dummy fill values are -9999.

APPENDIX I

SC11 Magnetic Field Data Base Format

Header Record

0.1	Integer (6) - Number of words in each group (6)	(I)
0.2	Integer (1) - Number of groups/record (1)	(I)
1	SCATHA bbbb	A
2	SC11ECI/SM	A
3	Year (last 2 digits of 19xx)	F
4	Day of year	F
5	Month	F
6	Day of month	F

Data Records

(Two integer words followed by all floating point values)

0.1	Integer (35) - Number of words/group	(I)
0.2	Integer (<14) - Number of groups/record	(I)
1	UT (seconds)	
2	B_x	15 second averages of SC11 data in ECI (from agency tape)
3	B_y	
4	B_z	
5	$\sqrt{B_x^2 + B_y^2 + B_z^2}$	
6	B_x	Model field (total) components from ephemeris file
7	B_y	
8	B_z	
9	$\sqrt{B_x^2 + B_y^2 + B_z^2}$	
10	Local time (hrs)	
11	Magnetic time (hrs)	
12	Mag. Lat (deg)	
13	L-Shell (er)	

Data Records (Cont.)

14	Latitude (deg)	
15	Longitude (deg)	
16	K_p*3	
17	Alt (km)	
18	SM Latitude (deg)	
19	SM Local time (hrs)	
20	GSM Latitude (deg)	
21	GSM Local time (hrs)	
22	S_x	Sun vector components (ECI)
23	S_y	
24	S_z	
25	M_x	Dipole moment components (ECI)
26	M_y	
27	M_z	
28	B_x	~15 sec avg. mag. field values in SM coordinates
29	B_y	
30	B_z	
31	$\sqrt{B_x^2 + B_y^2 + B_z^2}$	
32	B_x	
33	B_y	Model field values in SM coordinates
34	B_z	
35	$\sqrt{B_x^2 + B_y^2 + B_z^2}$	

One file per day processed was created.

There will be, in general, 14 groups of 35 words per record. The last group on any file may have less than 14 groups.

APPENDIX J

CRL-251 (P78-1) Data Base Format

P78-1 CRL-251 Data Base

The data base for the CRL-251 consists of 6 files for each agency tape which was processed.

The first 4 files were direct copies of files from the agency tape. The fifth file is the B&L file associated with the orbit. The sixth file contains raw and reduced parameters from the CRL-251. A header record is present on the sixth file.

File Structure:

F_1 = Header file from agency tape

F_2 = Scan file from agency tape

F_3 = Event file from agency tape

F_4 = EM file from agency tape

F_5 = B&L

F_6 = CRL-251 file

CRL-251 File Header Record

0.1	Word count - integer (6)	
0.2	Group count - integer (1)	
1	P78-1 (right adjusted)	A
2	CRL-251 (right adjusted)	A
3	Orbit Number	F
4	Day of year of orbit	F
5	Month of orbit	F
6	Day of orbit	F
7	Year (last 2 digits of 19xx) of orbit	F
8	Start time of pass (GMT seconds)	From
9	End time of pass (GMT seconds)	agency tape
10	E_1	
11	E_2	
12	E_3	
13	E_4	The 15 energy values associated
14	E_5	with the channels from
.	.	both detectors
.	.	
.	.	
24	E_{15}	
25	0.	
26	ΔE_1	
27	ΔE_2	
28	ΔE_3	The 15 ΔE values (associated with
29	ΔE_4	each of the energy channels. These values
.	.	used in calculation of JTOT, JETOT, EAVE.
.	.	
.	.	
40	ΔE_{15}	
41	0.	
42	K_1	
43	K_2	
44	K_3	Geometric facators for each of
45	K_4	the energy channels $(cm^2\ sec\text{-}sr\text{-}kev)^{-1}$
.	.	
.	.	
.	.	
57	K_{16}	

58	Run date of file creation	
59	Run time of file creation	
60	α_1 Mount angles used in LOS	F
61	β_1 determination for detector 1	F
62	α_2 Mount angles for detector 2	F
63	β_2	F
64	Playback rev. (e.g. Cook 123) (from agency tape)	A
65	Frame rate (milliseconds/frame) (from agency tape)	F
66	Vacant	

CRL-251 Data Records

Word No.	Description
0.1	Word count (179)
0.2	Group count (2)
1	GMT (sec) at start of masterframe
2	Altitude (km) at start of masterframe
3	Longitude (+E) at start of masterframe
4	Geocentric latitude at start of masterframe
5	Geomagnetic latitude at start of masterframe
6	Invariant latitude at start of masterframe
7	Local time (seconds) at start of masterframe
8	Magnetic local time (seconds) at start of masterframe
9	Magnetic field (total) from B&L file at start of masterframe
10	Corr. Geom. Lat.

The next 10 words are from the first spectra from det.

Word No.	Description
11	JTOT
12	JETOT
13	EAVE
14	Pitch angle of particle (180-detector P.A.)
15	Angle with velocity vector (detector to velocity vector)
16	Sun angle (angle between detector & sun)

17	bits 1-15	counts for detector 1 from first set of 16 readouts in masterframe. Word order is same as $E_1, E_2, \ldots, E_{16}$
	16-30	
	31-45	
	46-60	
18	bits 1-15	
.		
.		
.		
20	bits 46-60	

21	Same word order as 11 thru 20 for first spectra from detector 2
.	
.	
.	
30	

Word No.	Description
31-40	Detector 1 spectra 2
41-50	Detector 2 spectra 2
51-60	Detector 1 spectra 3
61-70	Detector 2 spectra 3
71-80	Detector 1 spectra 4
81-90	Detector 2 spectra 4
91-100	Detector 1 spectra 5
101-110	Detector 2 spectra 5
111-120	Detector 1 spectra 6
121-130	Detector 2 spectra 6
131-140	Detector 1 spectra 7
141-150	Detector 2 spectra 7
151-160	Detector 1 spectra 8
161-170	Detector 2 spectra 8
171	bits 1-15 21HVA1 (counts) from MF112 subframe 1
	16-30 21HVA2 (counts) from MF112 subframe 10
	31-45 21HVA3 (counts) from MF112 subframe 19
	46-60 21HVA4 (counts) from MF112 subframe 28
172	bits 1-15 21HVB1 (counts) from MF112 subframe 37
	16-30 21HVB2 (counts) from MF112 subframe 46
	31-45 21HVB3 (counts) from MF112 subframe 55
	46-60 21HVB4 (counts) from MF112 subframe 64
173	bits 1-15 21+5 (counts) from MF112 subframe 9
	16-30 21DETT (counts) from MF112 subframe 2
	31-45 21PWRT (counts) from MF112 subframe 3
	46-60 PHI_1
174	bits 1-60 PHI_{2-5}
175	bits 1-45 PHI_{6-8}
	46-60 RHI_1
176	bits 1-60 RHI_{2-5} — PCM counts from magnetometer words on agency tape
177	bits 1-45 RHI_{6-8}
	46-60 QHI_1
178	bits 1-60 QHI_{2-5}
179	bits 1-45 QHI_{6-8}
179	bits 46-60 Vacant

Thus, there will be 360 words per record. (2 masterframes.)